DOES COCOA-FRUIT INTERCROPPING IMPACT INFESTATION BY THE COCOA MIRID BUG *SAHLBERGELLA SINGULARIS* (HEMIPTERA: MIRIDAE)?

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SUMMARY

Worldwide, crop monocultures have proven to be particularly susceptible to pests and diseases. In Africa, unshaded "pure" cocoa plantations are often highly damaged by mirids and consequently require intensive phytosanitary protection. The aim of this study was to assess the impact of an alternative agronomic practice, a cocoa-fruit intercropping system, on infestation by *Sahlbergella singularis*, the main pest of cocoa in Cameroon. We focused our study on the potential effect of fruit trees as physical barriers, limiting mirid infestation during the first years of plantation, when fruit trees are not yet developed enough to provide cocoa with shade. Over two consecutive years, we assessed mirid infestations in seven four-year-old plantations located in the Centre region of Cameroon. Plantations were about one-third ha and included lines with fruit trees (avocado, safou and citrus) replacing cocoa on a regular basis. Mirid infestation was assessed at the population peak through observation of individuals or recent damage on cocoa pods and shoots. Spatial pattern analysis was done with presence-absence data through join count analysis and permutation tests. Our results showed that 1) mirids were strongly aggregated at small distance and 2) the cocoa-fruit intercropping system presented here did not impact mirid distribution on cocoa. These studies contribute to the improvement of IPM strategies for cocoa mirids through a better knowledge of population dynamics of these pests in plantations with reasoned patterns.

INTRODUCTION

Worldwide, crop monocultures have proven to be particularly susceptible to pests and diseases. In Africa, unshaded "pure" cocoa plantations are often highly damaged by mirids and consequently require intensive phytosanitary protection. Plant diversification in agrosystems can be a sustainable and ecologically sound strategy for the management of pests and diseases on many crops (Ratnadass *et al.*, 2011). Hedgerow and intercropping demonstrated positive physical effects on crop infestation by insect pests, preventing them from entering the crop (Debras *et al.*, 2008) or disturbing insect movements through the crop (Hooks & Fereres, 2006).

The present study assesses the impact of an alternative agronomic practice, a cocoa-fruit intercropping system, on infestation by *Sahlbergella singularis*, the main pest of cocoa in Cameroon. We focused our study on the potential effect of fruit trees as physical barriers, disturbing mirid infestation during the first years of plantation, when fruit trees are not yet developed enough to provide cocoa trees with shade.

MATERIALS AND METHODS

Study sites and assessment of mirid infestation

Over two consecutive years, we assessed mirid infestation in seven four-year-old plantations located in the Centre region of Cameroon. Four plots were located near Bokito village (4°34'N and 11°06'E, Bak1, Bak2, Ked1 and Ked2) characterized by a bush-savannah vegetation type, and three plots in the forest area, near Ngat village (3°46'N and 11°49'E, Nga1 and Nga2). Plots were about 0.3 ha and consisted of rows of cocoa trees interspaced with rows of cocoa trees intercropped with fruit trees (avocado, citrus and safou). Mirid infestation was assessed at the population peak through observation of individuals or recent damage on cocoa pods, chupons and shoots (feeding lesions and dry leaves).

Statistical analyses

Spatial pattern analysis was done with presence-absence (1-0) data through join count analysis. For counting, we considered all the pairs of cocoa trees distant from two units along the rows, perpendicularly to the rows and on the diagonals of a two unit's edge square (figure 1). Two groups were distinguished: group 1 contains pairs of cocoa trees separated by a fruit tree and group 2 contains pairs of cocoa trees separated by a cocoa tree. The tested hypothesis is that fruit trees disrupt mirid movements between cacao trees. If this is true, correlation between pairs of cocoa trees separated by a fruit tree should be lower than the same correlation for a pair separated by a cocoa tree.

In each group, we calculated the proportion of pairs with mirids on each cocoa tree (1-1 pairs) among all the pairs of cacao trees (0-0, 0-1, 1-1). Then a criterion was calculated as the difference between proportion of pairs 1-1 in group 1 and proportion of pairs 1-1 in group 2. If fruit trees do not impact mirid moving, the expected value of the criterion is 0. A negative value of the criterion was interpreted as a barrier effect of fruit trees, whereas a positive value indicated an effect favoring mirid movement. The criterion is not impacted by mirid aggregation because in case of aggregation the proportion of pairs 1-1 is higher in the two groups.

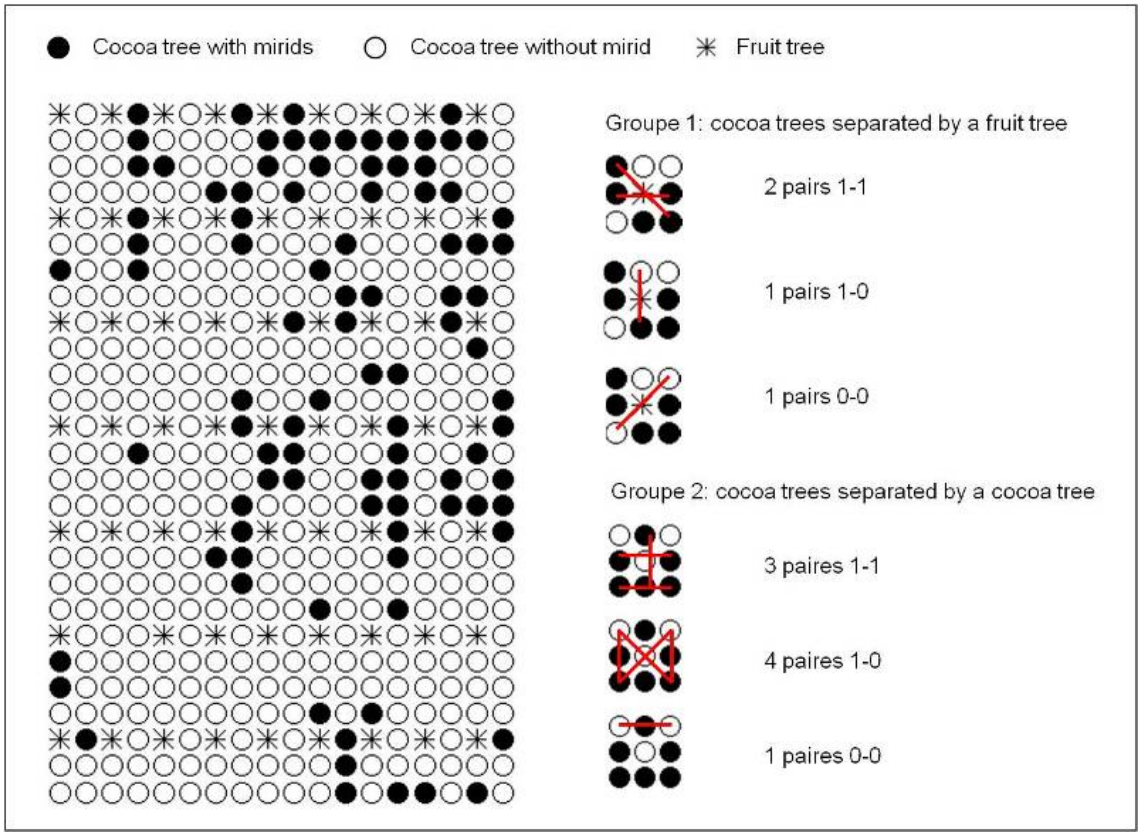

Figure 1: Infestation map for the plot Nga2, year 2009, and diagrams showing samples of join counts for the 2 groups of cocoa trees.

For testing criterion significance, we used the quantile value of the criterion in a distribution of simulated values obtained from 199 random permutations of presence/absence data, fruit tree positions and missing values being fixed. The observed value of the criterion was the 200th observation and the quantile was the observed criterion rank divided by 200. The barrier effect was significant if the quantile was lower than

the fixed value 0.05. We also tested mirid aggregation for pairs of the two groups taken as a whole, by calculating the global amount of 1-1 pairs in the observed configuration and in the simulations. Aggregation was significant if the quantile was lower than 0.05.

RESULTS

The estimated criterion for mirid aggregation (total join count) was significant for 11 of the 14 observations (Table 1). By contrast, the criterion for barrier effect was never significant. Only the plot Nga2, in 2009, showed a quantile value close to 0.05, but mirid infestation was particularly low for this plot, with less than 8% of trees infested.

Table 1: Criterion and quantile values for mirid aggregation and barrier effect, for the 7 plots and 2 years of observation

Plot	Year	Mirid aggregation		Barrier effect	
		Criterion value	Quantile value	Criterion value	Quantile value
Bak1	2009	22	0.005 *	-0.001	0.497 ns
	2010	10	0.323 ns	0.006	0.670 ns
Bak2	2009	57	0.005 *	-0.010	0.165 ns
	2010	33	0.028 *	-0.014	0.075 ns
Ked1	2009	26	0.005 *	0.021	0.920 ns
	2010	3	0.308 ns	-0.005	0.105 ns
Ked2	2009	33	0.005 *	0.001	0.535 ns
	2010	3	0.158 ns	0.005	0.837 ns
Nga1	2009	23	0.005 *	0.004	0.680 ns
	2010	72	0.005 *	0.008	0.605 ns
Nga2	2009	13	0.030 *	-0.011	0.052 ns
	2010	77	0.040 *	-0.036	0.127 ns
Nga3	2009	34	0.005 *	-0.005	0.370 ns
	2010	70	0.005 *	0.009	0.830 ns

*Significant

DISCUSSION CONCLUSION

Our results showed that mirids were strongly aggregated at small distance (a cocoa tree and its immediate neighbors). This confirms for unshaded plantations what has been demonstrated for traditional shaded cocoa-based agroforestry systems (Babin *et al.*, 2010).

Our results also suggest that, in the present intercropping pattern, fruit trees do not cause barrier effects towards mirid dispersion. Indeed, mirid distribution did not show any particularity which would have revealed physical barrier effect due to fruit tree position in plots. The relevance of the analysis method was checked with an additional test, performed with artificial presence/absence data simulating undeniable barrier effects. This test gave highly significant criteria, suggesting that the method was relevant and might be used for further analyses for different intercropping patterns.

To conclude, this study shows that the cocoa-fruit intercropping system presented here does not impact mirid distribution on cocoa. Thus, such cropping systems requires phytosanitary protection as intensive as

for unshaded “pure” cocoa, especially during the first years of plantation, when cocoa is especially vulnerable to mirid damage.

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